

Introduction

Chapter Overview

Many recommendations for strengthening higher education in science and engineering that were made a half-century ago in *Science and Public Policy*² are still being implemented or are still of national concern (Steelman 1947). These recommendations of the President's Scientific Research Board—referred to herein as the Steelman report—included expanding institutions of higher education, training scientists and engineers in all fields of knowledge, and providing U.S. leadership in disseminating scientific knowledge. This chapter suggests that several of these recommendations have been accomplished, as the trends regarding expansion of and greater access to higher education and the leadership role of U.S. universities in training scientists and engineers from around the world demonstrate. This chapter also addresses other recommendations that are still topics of concern, such as improving the teaching and research experience of undergraduates, educating adequate numbers of students willing and able to pursue advanced S&E programs, and creating the “right” number of S&E doctorates to meet the needs of the workplace. In addition, this chapter presents indicators on current concerns that are different from those of the past—especially the participation of women and minorities in S&E, the dependence on foreign students in U.S. graduate S&E programs, and the stay rates and return patterns of foreign doctoral recipients.

Chapter Organization

This chapter begins with a review of the growth of U.S. higher education from the early 1950s; this review presents the characteristics of the diverse set of institutions that fostered this growth. The chapter notes the prominence of research universities in the expansion of S&E degrees, as well as the continuing importance of comprehensive and liberal arts colleges. The review highlights increased access to higher education provided by community colleges.

The main body of the chapter presents trends in enrollment and degrees in broad fields of S&E at various levels—associate's, bachelor's, master's, and doctorate. The characteristics of U.S. freshmen show their intentions to major in S&E as well as some lack of readiness for college-level work. Following the review of bachelor-level trends, international data are presented to compare participation rates across several world regions. In addition, international comparisons are made at the doctoral level, and information is presented on the worldwide movement toward expansion and reform of graduate S&E education. Further international comparisons are made with regard to the participation of women in S&E fields at the bachelor's and doctoral levels and the proportion of doctoral degrees earned by foreign students.

The final sections of the chapter address patterns of diversity in U.S. higher education. The increasing representation of women and minorities in S&E degrees is shown over time and by field. Long-term trends of increasing foreign student enrollment and degrees, as well as recent downturns in these trends, are discussed.

Other chapters of this volume cover related topics in S&E education. Chapter 3, “Science and Engineering Workforce,” discusses the entry of S&E graduates at various levels into the U.S. labor force in S&E occupations and the contribution of foreign doctoral recipients who remain in the United States for teaching and research. Chapter 6, “Academic Research and Development,” includes indicators of graduate student financing, faculty composition, and the link between R&D funding and graduate enrollment; the bibliometric section of that chapter also provides initial indicators of the growing percentage of the world's scientific literature from countries expanding their graduate education in S&E. Chapter 7, “Industry, Technology, and the Global Marketplace,” provides initial indicators of competitiveness—high technology trade and patenting—of countries that have expanded their doctoral S&E training and are building their science infrastructure. Chapter 9, “Significance of Information Technologies,” includes the impact of technology on higher education.

Characteristics of U.S. Higher Education Institutions

The defining characteristics of U.S. higher education that foster access—a broad array of institutional types and sizes, public and private funding, and flexible attendance patterns—were already in place in the early 1950s. In 1953, more than 1,870 institutions—including universities; liberal arts colleges; teachers' colleges; and technological, theological, and other professional schools—were providing higher education. These diverse institutions included public and private colleges and universities and provided for part-time attendance. One-fifth of the undergraduate students were enrolled part-time (U.S. HEW 1956). Students were concentrated in universities and liberal arts colleges; only 13 percent were enrolled in junior colleges. (See text table 4-1.)

Expansion of Institutions

These underlying characteristics of U.S. higher education have persisted during the past 50 years, with expansion occurring through the establishment of many new institutions and the increasing size of universities. In 1953, the largest universities enrolled approximately 10,000 students. By 1996, the largest U.S. universities enrolled between 25,000 and 50,000 students (HEP 1996). Enrollment has surged within research and comprehensive universities. A number of teachers' colleges expanded their offerings and became comprehensive and doctoral institutions. While the number of universities has doubled since the 1950s, the number of two-

²See chapter 1.

Text table 4-1.

U.S. institutions of higher education, by type and enrollment level: 1953

Type	Number	Enrollment
Total	1,871	2,534,709
Universities	131	1,154,719
Liberal arts colleges	713	636,479
Teachers' colleges	200	208,573
Technological schools	53	114,077
Theological schools	115	31,205
Other professional	138	61,986
Junior colleges	498	339,867

SOURCE: U.S. Department of Health, Education, and Welfare (HEW), *Statistics of Higher Education: Faculty, Students, and Degrees 1953–54* (Washington, DC: U.S. Government Printing Office, 1956).

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year institutions has tripled—from 521 in 1953 to 1,569 in 1996 (HEP 1996). (See figure 4-1.)

Alongside the growth of large institutions in U.S. higher education, liberal arts institutions have remained relatively small. In 1953, liberal arts colleges enrolled approximately 0.6 million students in 713 institutions. By 1996, 1.1 million students were enrolled in approximately 637 such undergraduate colleges (reflecting an average enrollment of less than 2,000 students).

Today's large and diversified set of institutions provides an education at the bachelor's level to approximately one-third of the U.S. college-age population. (See "Undergraduate S&E

Students and Degrees in the United States.") Access to U.S. higher education is still among the highest in the world, although other countries are also broadening access and expanding graduate programs, particularly in S&E. (See "International Comparison of First University Degrees in S&E," "International Comparison of Doctoral Degrees in S&E," and sidebar, "Graduate Reforms in Europe, Asia, and Latin America.")

In the United States, there were 3,660 (1,580 public and 2,080 private) two- and four-year institutions of higher education in 1996 (HEP 1996). These institutions enrolled 14.5 million students at all degree levels in that year and awarded 2.2 million degrees, one-quarter of which were in S&E. (See figure 4-2.)

More than 5 million of the 14.5 million students are enrolled in community colleges. These institutions increase the openness of U.S. higher education; through considerable remedial coursework, they provide a second chance for students who were not well served by, or well motivated during, their high school education. They also foster movement into four-year institutions through arrangements that allow students to transfer their credits from community colleges to four-year colleges and universities.

To better describe this diverse set of institutions serving a variety of needs, the Carnegie Foundation for the Advancement of Teaching has clustered institutions with similar programs and purposes. (See sidebar, "Carnegie Classification of Institutions.")

Long-Term Trends in Enrollment in U.S. Higher Education

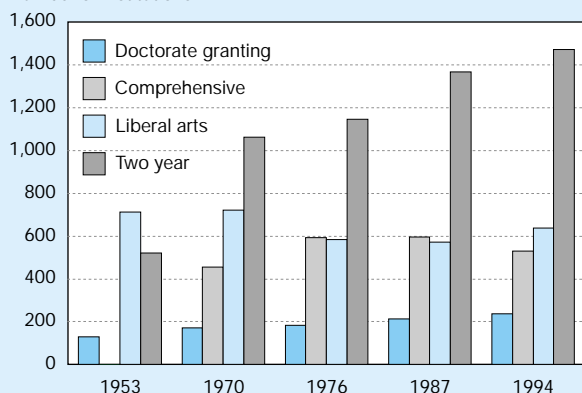
The four-decade expansion in enrollment in U.S. higher education reached its peak in 1992, when more than 14.6 million students were enrolled, and then leveled off. This expansion first accelerated in the late 1940s and early 1950s; by 1950, higher education enrollment had surged to 2.7 million students (up from 1.2 million in 1944) as a result of the post-World War II influx of veterans supported under the GI Bill (U.S. HEW 1956).³ After the influx of returning veterans subsided, the number of (nonveteran) college students grew steadily for several decades, from the 1960s to the early 1990s, reaching a peak of more than 14.6 million students in 1992. Following more than four decades of such growth in higher education, graduate enrollment began a slight decline in 1993; undergraduate enrollment began declining in 1995. (See "Undergraduate S&E Students and Degrees in the United States" and "Graduate S&E Students and Degrees in the United States.")

From 1967 to 1992, enrollment in U.S. institutions of higher education expanded an average of 3 percent annually, but growth rates differed greatly by type of institution. For example, two-year colleges grew at twice this rate and accounted

Figure 4-1.

Number of institutions of higher education, by type: 1953–94

Number of institutions

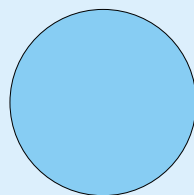
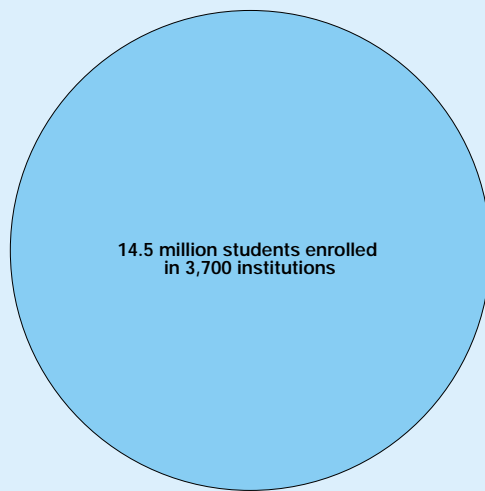


NOTES: Universities were not categorized as "comprehensive" in 1953; 1953 data on institutional categories are not strictly comparable with the later data, which are based on the Carnegie Classification of Education. A number of comprehensive universities became doctorate-granting institutions between 1987 and 1994.

See appendix table 4-1. *Science & Engineering Indicators – 2000*

³In that year, 1950, veterans represented 35 percent of the students in higher education.

Figure 4-2.
U.S. higher education in 1996: students, institutions, and degrees at all levels



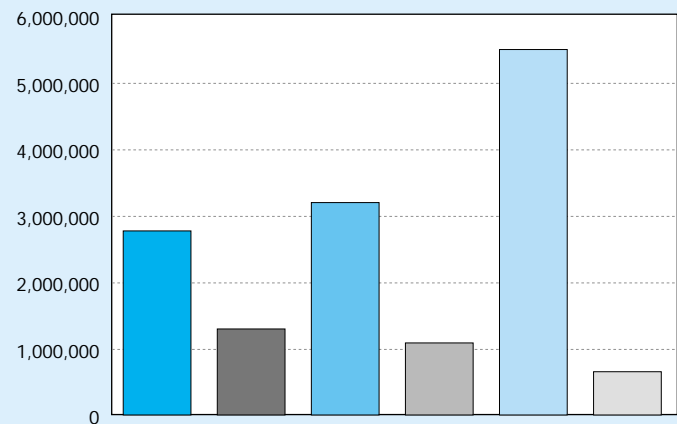
of which:

24,600	Associate's degrees
384,674	Bachelor's degrees
95,313	Master's degrees
26,847	Doctorate degrees

- In 126 research I & II research institutions
- In 109 doctorate-granting I & II institutions
- In 527 master's universities and colleges I & II
- In 625 liberal arts I & II institutions
- In 1,569 two-year institutions
- In 389 specialized institutions

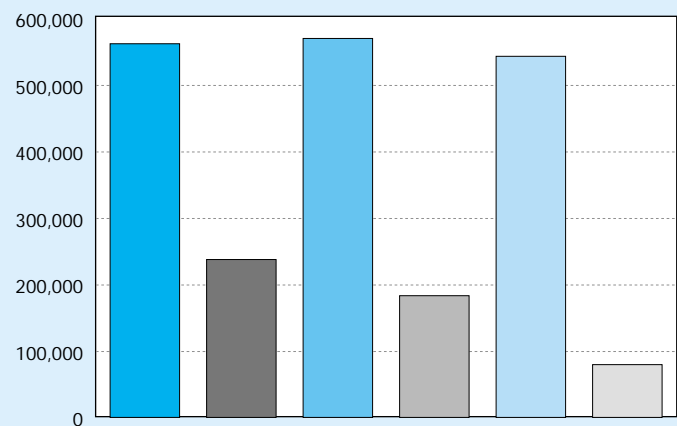
Where are they enrolled?

Enrollment



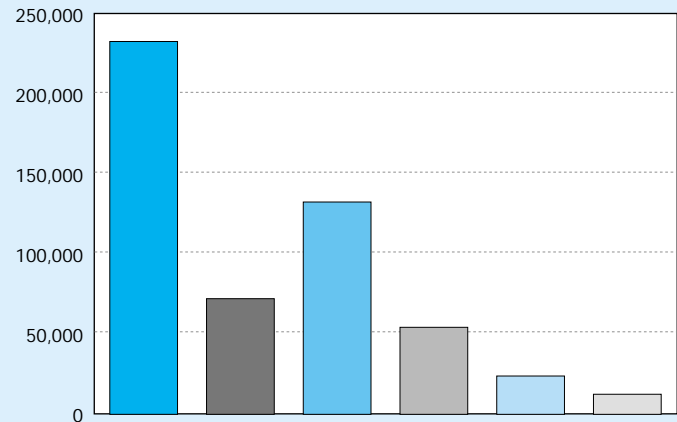
How many degrees do they obtain?

Number of degrees



How many degrees in S&E?

Number of degrees



NOTE: The 355 institutions classified as "other" are not included.

See appendix tables 4-2, 4-3, and 4-4.

Carnegie Classification of Institutions

Carnegie has classified higher education institutions into 10 categories based on the size of their baccalaureate and graduate degree programs, the amount of research funding they receive, and—for baccalaureate colleges—their selectivity.* Following is a brief description of these categories.

- ♦ **Research universities I.** These institutions offer a full range of baccalaureate programs, are committed to graduate education through the doctorate level, and give high priority to research. They award 50 or more doctoral degrees each year and annually receive \$40 million or more in Federal research support.
- ♦ **Research universities II.** These institutions are the same as research I universities, except that they receive between \$15.5 million and \$40 million annually in Federal research support.
- ♦ **Doctorate-granting I.** In addition to offering a full range of baccalaureate programs, the mission of these institutions includes a commitment to graduate education through the doctoral degree. They award 40 or more doctoral degrees annually in at least five academic disciplines.
- ♦ **Doctorate-granting II.** These institutions are the same as doctorate-granting I institutions, except that they award 20 or more doctoral degrees annually in at least one discipline or 10 or more doctoral degrees in three disciplines.
- ♦ **Master's (comprehensive) universities and colleges I.** These institutions offer baccalaureate programs and,

with few exceptions, graduate education through the master's degree. More than half of their baccalaureate degrees are awarded in two or more occupational or professional disciplines, such as engineering or business administration. All of the institutions in this group enroll at least 2,500 students.

- ♦ **Master's (comprehensive) universities and colleges II.** These institutions are the same as master's universities and colleges I, except that all of the institutions in this group enroll between 1,500 and 2,500 students.
- ♦ **Baccalaureate (liberal arts) colleges I.** These highly selective institutions are primarily undergraduate colleges. They award more than 40 percent of their baccalaureate degrees in liberal arts and science fields.
- ♦ **Baccalaureate (liberal arts) colleges II.** These institutions are primarily undergraduate colleges that award less than 40 percent of their degrees in liberal arts and science fields. They are less restrictive in admissions than baccalaureate colleges I.
- ♦ **Associate of arts colleges.** These institutions offer certificate or degree programs through the associate degree level and, with few exceptions, offer no baccalaureate degrees.
- ♦ **Professional schools and other specialized institutions.** These institutions offer degrees ranging from the bachelor's to the doctorate. At least half of the degrees awarded by these institutions are in a single specialized field. These institutions include theological seminaries, bible colleges, and other institutions offering degrees in religion; medical schools and centers; other separate health profession schools; law schools; engineering and technology schools; business and management schools; schools of art, music, and design; teachers' colleges; and corporate-sponsored institutions.

*The Carnegie classification is not an assessment guide, nor are the distinctions between classification sublevels (for example, research I and research II) based on institutions' educational quality. Baccalaureate college I institutions exercise more selectivity regarding students than do baccalaureate colleges II, but in general the Carnegie categories are a typology, not a rank ordering.

for the largest share of the growth—from 0.2 million students in 1950 to 5.5 million students in 1996. (See appendix table 4-2 and U.S. HEW 1956.) In 1950, two-year college enrollment was 9 percent of overall higher education enrollment. By 1996, enrollment in two-year colleges was 38 percent of higher education's total enrollment. In contrast, student enrollment in research I universities grew more modestly, from 1.5 million students in 1967 to 2.1 million in 1991 (with slight declines since then).⁴ Research universities enroll only 19 percent of the students in higher education, but they play the

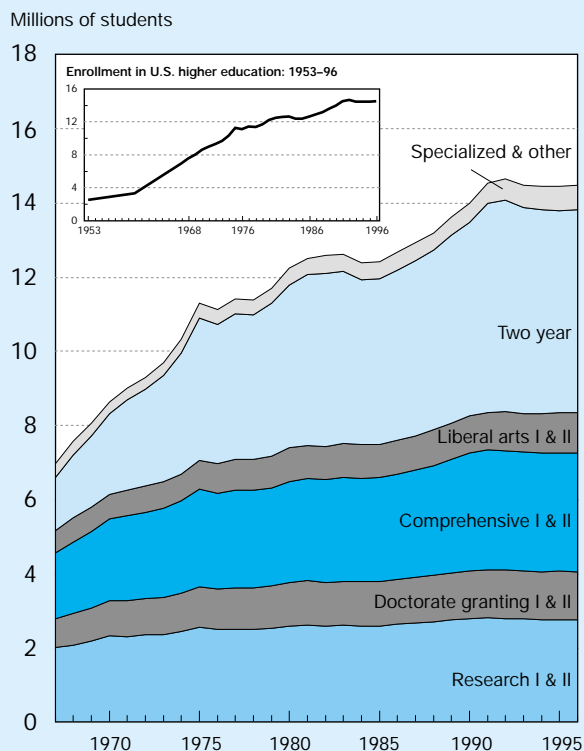
largest role in S&E degree production. (See figure 4-3 and appendix table 4-2.)

S&E Degree Production by Type of Institution

A diverse spectrum of institutions provides for relatively high access to higher education in the United States, but the research-intensive universities produce the majority of engineering degrees and a large proportion of natural and social science degrees at both the graduate and undergraduate levels. (See figures 4-4 and 4-5.) In 1996, the country's 126 research universities awarded more than 42 percent of all S&E degrees at the bachelor's level and 52 percent of all S&E degrees at the master's level. (See appendix table 4-3.) In addi-

⁴Research institutions, however, account for significant numbers of S&E degrees; two-year colleges do not. (See figure 4-2 and "S&E Degree Production by Type of Institution.")

Figure 4-3.
Enrollment in U.S. higher education,
by institution type: 1967–96



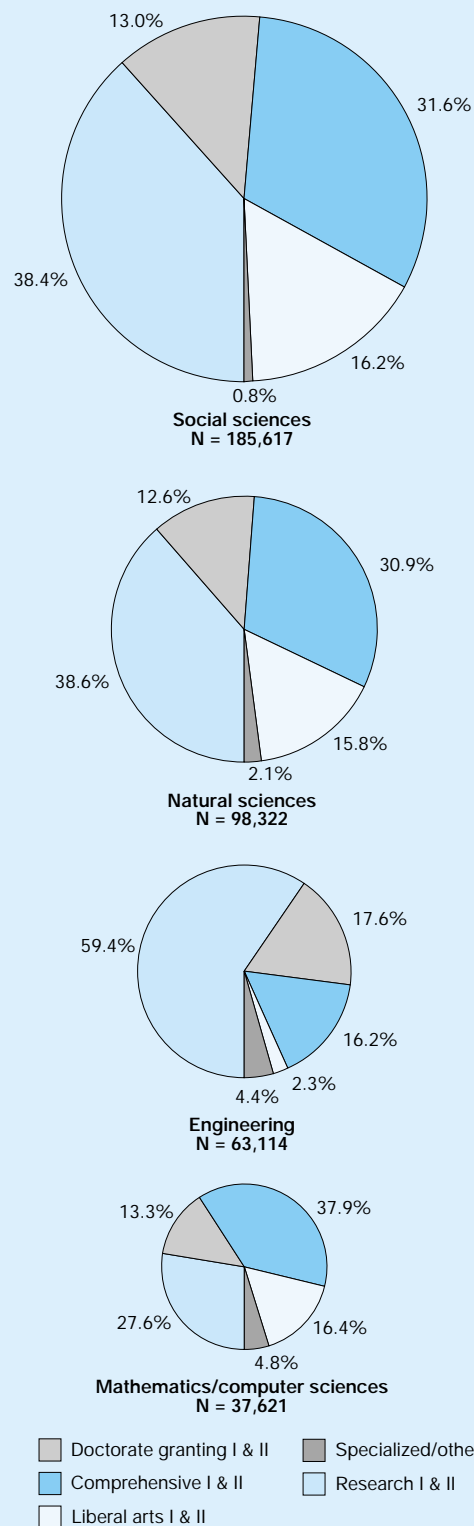
See text table 4-1 and appendix table 4-2.

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tion, comprehensive and liberal arts I institutions produce significant numbers of bachelor's and master's degrees in science and engineering. (See appendix table 4-3.)

The proportion of S&E degrees earned by institution type in U.S. higher education, however, is not homogeneous for all groups. In contrast to the overall student population, S&E degrees earned by underrepresented minorities are less concentrated in research universities; minority-serving institutions still play a significant role in minorities' S&E education. These students earn a far smaller percentage of their bachelor-level degrees in the natural and social sciences at research universities, compared with their engineering degrees and with the percentage of such degrees earned by the overall student population. Over the past 20 years, underrepresented minority students have earned higher percentages of their degrees within research universities in social science and engineering fields, but not in natural science fields. By 1996, underrepresented minority students earned 44 percent of their bachelor-level engineering degrees at research universities, up from 32 percent in 1977. (See appendix table 4-5.) However, the relatively small percentages of degrees earned by underrepresented minority students within research universities have remained stable over the past 20 years. (See appendix table 4-5 and text table 4-2.)

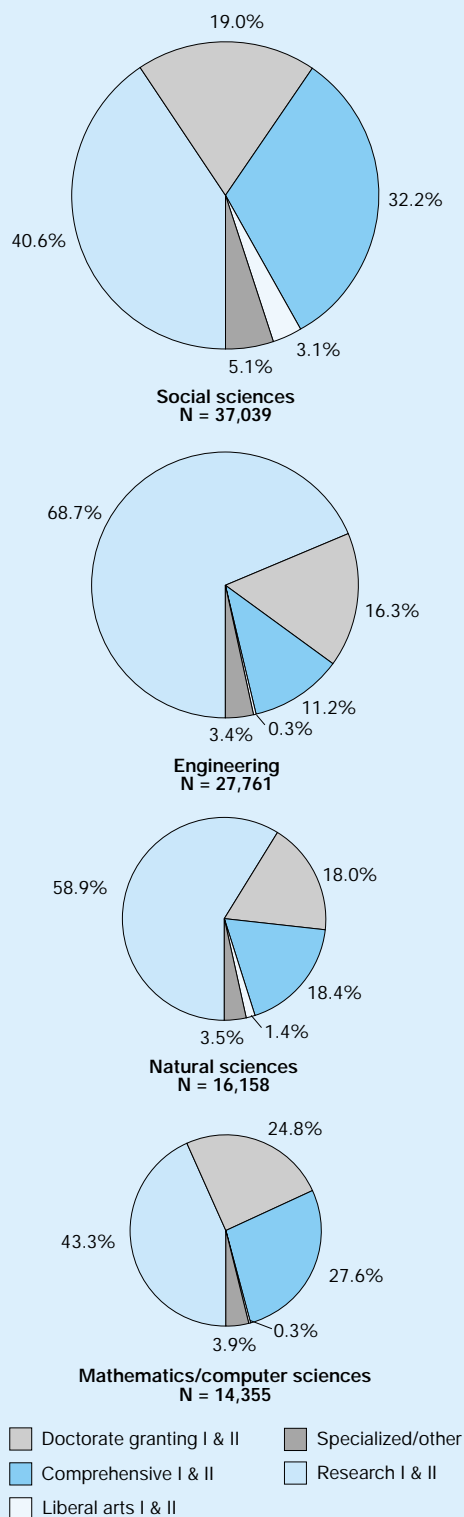
Figure 4-4.
Bachelor's degrees awarded in S&E, by institution
type: 1996



NOTES: Natural sciences include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences. Social sciences include psychology, sociology, and other social sciences.

See appendix table 4-3. Science & Engineering Indicators – 2000

Figure 4-5.
Master's degrees awarded in S&E, by institution
type: 1996



NOTES: Natural sciences include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences. Social sciences include psychology, sociology, and other social sciences.

See appendix table 4-3. *Science & Engineering Indicators – 2000*

Text table 4-2.

Percentage of S&E bachelor's degrees earned by underrepresented minorities within research universities: 1996

Field	Total student population	Underrepresented minorities
Total S&E	42	31
Natural sciences	39	25
Social sciences	38	32
Engineering	60	44

See appendix tables 4-3 and 4-5.

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Black students have traditionally earned a large percentage of their S&E degrees within historically black colleges and universities (HBCUs)—mainly comprehensive universities and liberal arts colleges. HBCUs, originally established during the period of legalized segregation for the purpose of educating blacks, continue to produce large percentages of the S&E bachelor-level degrees earned by black students. These comprehensive universities and liberal arts colleges produce 30 percent of their engineering degrees, 44 percent of their natural science degrees, and 25 percent of their social science degrees. These percentages have remained relatively stable for the past 20 years. (See appendix table 4-5 and NSF 1999c.)

The associate of arts colleges, which enroll more than 5 million students, account for only a small percentage of S&E degrees. These two-year colleges, however, provide continuing education and flexibility in the U.S. higher education system, allowing students to complete required work-related courses or obtain coursework credits for transfer to a four-year college or university. An analysis of undergraduate careers in engineering in 1995 showed that one out of six students who received a bachelor's degree in engineering, engineering technology, or architecture started in a community college (USDE 1998).

Baccalaureate Origins of Ph.D.s

The 126 research universities provide the baccalaureate education of the majority (56 percent) of S&E doctoral recipients. However, liberal arts colleges and comprehensive universities also contribute a significant proportion of bachelor-level degrees among students who later complete doctoral S&E degrees. Each of these institution types provides 15 percent of the baccalaureate education of doctoral recipients; within individual fields they are even more prominent. For example, 23 percent of the students earning doctorates in chemistry received their undergraduate education within a liberal arts college, and an additional 23 percent received their undergraduate education within a comprehensive university. (See appendix table 4-6.)

Demographics and U.S. Higher Education

The U.S. college-age population has declined by more than 21 percent in the past two decades, from 21.6 million in 1980 to 17.0 million in the year 2000. This demographic decline is reflected in the trends presented in this chapter, including the declining number of bachelor's degrees in several fields of NS&E beginning in the late 1980s. (See figure 4-6.) This 20-year population decline of the college-age cohort reverses itself in the year 2000, and increases to 19.3 million by the year 2010. (See appendix table 4-7.) The increase in the college-age population by more than 13 percent in the first decade of the 21st century portends another wave of expansion in U.S. higher education—and growth in S&E degrees at all levels.

Undergraduate S&E Students and Degrees in the United States

Characteristics of American College Freshmen

Intentions to Major in S&E

The issue of whether women and minorities are attracted to S&E majors is of national interest because they now make up the majority of the labor force. Their successful completion of S&E degrees will determine the adequacy of entrants into the S&E workforce in the United States. This section reports on two longitudinal surveys of student intentions to major in S&E, by race, ethnicity, and sex. (See “Bachelor's Degrees,” “Trends in Earned S&E Degrees.”) The Higher Education Research Institute's (HERI) Freshman Norms Survey annually surveys a nationally representative sample of first-year students in four-year colleges and universities about their intention to major in any S&E field (HERI 1998). The National Education Longitudinal Study of 1988 (NELS:88 unpublished tabulations) tracked a large, nationally representative sample of eighth graders and identified in a follow-up survey those who were enrolled in undergraduate S&E programs (NCES 1998b).

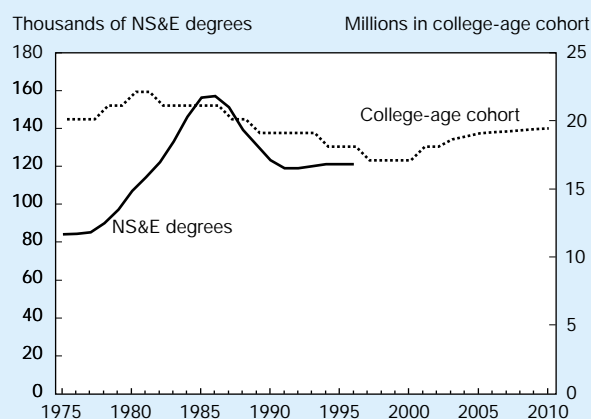
The Freshman Norms data show that, by 1998, 47 percent of the first-year college students reporting intentions to major in S&E were women; 53 percent were men (HERI 1998). These data also show increasing racial diversity among students choosing an S&E major. By 1998, underrepresented minority groups represented 19 percent of those intending an S&E major,⁵ up from 8 percent in 1971. The trend is toward an increased percentage of black and Hispanic freshmen intending a natural science or engineering major. (See appendix table 4-9.) For example, from 1986 to 1998, the proportion of underrepresented minorities intending to major in the bio-

logical sciences rose from 10 percent of first-year college students to 18 percent.⁶ (See appendix table 4-9.)

NELS:88 corroborated the findings of the Freshman Norms Survey and showed little difference between racial and ethnic groups with regard to choosing an S&E major. NELS:88 followed students from eighth grade through high school, college, and entry into the labor force. Students who reported being enrolled in an S&E program (generally as sophomores in college) were examined to identify differences by race and sex. Between 9 and 10 percent of all racial/ethnic groups of this cohort were enrolled in S&E programs in 1994. In contrast, the study found a significant difference in the percentage of males and females enrolled in S&E programs: 12 percent of males were enrolled in such programs, whereas only 7 percent of females were enrolled in S&E fields. The gap between males and females is particularly pronounced among (or attributable mainly to) the gaps among white and Asian/Pacific Islander students; among black and Hispanic students, women are essentially on par with men. (See figure 4-7.)

Of the relatively small percentage of students who enroll as S&E majors, less than one-half complete an S&E degree within 5 years. (See “Diversity Patterns in S&E Enrollment and Degrees in the United States.”) Although there may be many reasons for this, the disparity between the percentage of students who aspire to study S&E fields and the percentage who complete an undergraduate S&E degree reflects, in part, the lack of readiness of U.S. students for college-level S&E coursework.

Figure 4-6.
Trends in U.S. college-age cohort and bachelor's degrees in selected NS&E fields: 1975–2010



NOTES: NS&E = natural science and engineering. College-age cohort = the 20–24-year-old population. Selected natural sciences include physical, earth, atmospheric, and oceanographic sciences, mathematics, and computer sciences.

See appendix tables 4-7 and 4-17, and National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees: 1966–96*, NSF 99-330, Author, Susan T. Hill (Arlington, VA, 1999).

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⁵In 1996, white students constituted 67 percent of the 18-year-old population in the United States; underrepresented minority groups constituted 29 percent (U.S. Department of Commerce, Bureau of the Census 1998).

⁶Underrepresented minority students are not uniformly distributed across all institutions, however. They are more concentrated in minority-serving institutions (comprehensive universities and liberal arts colleges) and HBCUs. (See “S&E Degree Production by Type of Institution.”)